Laminar-Turbulent Transition: A Hysteresis Curve of Two Critical Reynolds Numbers in Pipe Flow HIDESADA KANDA, University of Aizu

— A laminar-turbulent transition model (DFD 2004) has been constructed for pipe flows: (1) Natural transition occurs in the entrance region, and (2) Entrance shape determines a critical Reynolds number $R_c$. To verify the model, we have carried out experiments similar to Reynolds’s color-dye experiment with 5 bellmouth entrances and a straight pipe. Then, we observed the following: (i) two different types of $R_c$ exist, $R_{c1}$ from laminar to turbulent and $R_{c2}$ from turbulent to laminar, and (ii) the ratio of bellmouth diameter $B_D$ to pipe diameter $D$ affects the values of $R_{c1}$ and $R_{c2}$. For each entrance, $R_{c1}$ has a maximum value $R_{c1}(\text{max})$ and $R_{c2}$ has a minimum value $R_{c2}(\text{min})$. When overlapping the two curves of $R_{c1}(\text{max})$ and $R_{c2}(\text{min})$ against $B_D/D$, a hysteresis curve is confirmed. All $R_c$ values exist inside this hysteresis curve. Consequently, $R_c$ takes a minimum value $R_{c}(\text{min})$ of approximately 2000 when $B_D/D$ is at a minimum, i.e., at $B_D/D = 1$, $R_{c}(\text{min}) = R_{c1}(\text{max}) = R_{c2}(\text{min}) = 2000$. Regarding Reynolds’s $R_c$ of 12,830, we observed $R_{c1}(\text{max})$ of approximately 13,000 at $B_D/D$ above 1.54. Therefore, the model has been partly verified.

Hidesada Kanda
University of Aizu

Date submitted: 26 Jul 2006